

Ecogeographical characteristics of forest soil animal in mountainous districts of the eastern China

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Abstract: In this paper ecogeographical characteristics of forest soil animal in mountainous districts of the eastern China was analyzed, and results show that soil fauna was very rich in diversified forest habitat, moreover, as times and spaces varied, their compositions and abundance changed obviously too. Forest soil animal decreased gradually in taxa and individual number from the tropics to cold-temperature zone, and they are higher in zonal forest habitat than in other ones on the same mountain. Forest soil animal also got gradually less with increasing of depth in soil layer, and distributed principally in surface layer. The activities of human had strong affection on faunal composition and diversity of soil animal. On the tropics and subtropics mountains, forest soil animal are less in spring-summer than in autumn-winter, whereas they are more in summer-autumn than in winter-spring from warm-temperate zone to cold-temperate zone.

Key word: Forest soil animal; Faunal characteristics; Ecogeographical distribution; Eastern China

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Introduction

There are various soil animals that live in the soil of earth's land surface. In past several decades, a large numbers of studies showed that soil animal have important significance for form of soil, material circulation, energy transformation and biological decomposition of some poisonous matters (Yin *et al.* 1992; Beare *et al.* 1995; Chen & Fu 1984). Forest soil animals are important component of forest ecosystem and play an important role in protecting and developing forest ecosystem and maintaining ecological balance. This paper based on collecting and analyzing a great deal of data of studying soil fauna in China and combining with our study on soil animals in the mountain of warm-temperate zone, analyzed and inquired for ecogeographical characteristics of forest soil animal in mountains of the eastern China. It aims to clarify ecogeographical law of soil fauna and the relationship between soil animals and forestry environments, and promote further study on ecological function of soil animals in forest ecosystem of mountainous districts of the eastern China.

Study area

Because eastern of China is influenced by oceanic

weather, rainfall is rich and air humidity is higher, forest vegetations grow very well. Based on obtaining different quantity of heat, the eastern region in China is divided into the tropics, subtropics, warm-temperate zone, temperate zone and cold-temperate zone from south to north. Adapted to each local environment, relevant types of forest and soil were developed in different mountainous districts of the eastern China (ECCPGCAS 1985; Jiang *et al.* 1990) (Table.1).

Ecological characteristics of forest soil animal fauna

Because soil animal studies in China started lately, most soil animals were only identified to order and family level. According to investigating data of soil fauna, forest soil animal in the eastern mountains belongs to 8 phyla and 14 classes (Zhao & Xie 1996; Yuan & Liu 2000; Zhang *et al.* 1990; Liao & Chen 1989a, 1989b; Zhang *et al.* 1980; Chen 1990). As for arthropods, there were 7 classes in this region and account for 77.78% of the total classes of Arthropoda. Insecta is the greatest class in the animal kingdom and there are 34 orders. However there were 19 orders of insecta in this region, accounting for 55.88% of the total orders of insecta. Most of higher taxa of forest soil animal in the eastern mountains such as class and order distributed over each mountain. In district plan of natural geography, this region belongs to the eastern monsoon region, hence, rainfall is much more and relative humidity is higher. Comparing with drought sandlot and grassland of western

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area, there are more soil animals such as *Rotatoria*, *Turbellaria*, *Diplopoda* and *Enchytraeidae*, and so on, which are fond of moist environments. In the total forest soil fauna of mountainous districts of the eastern China, the large-sized soil animal mainly included *Diplopoda*, *Chilopoda*, *Gastopoda*, *Oligochaeta*

opisthopora, *Araneae*, *Blattoptera*, *Dermaptera*, *Hemiptera*, *Lepidoptera*, *Hymenoptera*, *Coleoptera* and *Enchytraeidae*. *Nematoda*, *Rotatoria*, *Turbellaria*, *Acarina*, *Symphyla*, *Protura*, *Collembola*, *Psocoptera* etc. were the principal middle-small-sized soil animals.

Table 1. Principal types of forest and natural conditions in the mountainous regions of East China

Zone of temperature	Annual average temp. /°C	Annual average precipitation /mm	Type of zonal forest	Type of mountainous forest	Type of zonal soil	Type of mountainous soil
Tropical zone	22-26	1500-3000	Tropical rain forest	Mountain rain forest; Evergreen Seasonal rain forest; Semideciduous seasonal rain forest (Jianfengling Mt.)	Acid laterite	Laterite, Yellow soil
Southern subtropical zone	20-22	1000-2000	Evergreen seasonal rain forest	Pine and broad-leaf mixed forest (Dinghushan Mt.)	Acid lateritic soil	Laterite
Subtropical zone	16-21	1000-2000	Evergreen broad-leaf forest	Deciduous low forest; Evergreen and deciduous mixed forest; Evergreen broad-leaf and pine-leaf mixed forest; Pine forest (Tianmu Mt.; Hengshan Mt.)	Yellow soil Yellow —brown soil	Mountain yellow brown soil Mountain yellow soil; Yellow low-red soil; Red soil
Warm-temperate zone	10-15	600-1000	Deciduous broad-leaf forest	<i>Pinus tabulaeformis</i> forest; Deciduous broad-leaf and pine-leaf mixed forest; Secondery forest (Taishan Mt.)	Brown soil	Mountain brown soil dark soil; Mountain brown dark soil
Temperate zone	2-7	450-800	Pine and broad-leaf Mixed forest	Secondery forest; Betula forest; Pine forest (Changbaishan Mt.)	Brown dark soil	Subalpine soddy forest soil; Mountain brown taiga soil; Mountain brown forest dark soil; Lessive
Cold-temperate zone	-2.0-5.0	400-500	Deciduous pine-leaf forest	Pine-leaf and broad-leaf mixed forest (Xiaodongshan Mt.)	Acid brown taiga soil	Brown taiga soil

Whereas, forest soil fauna of mountainous district of the different latitude zones were different. *Isoptera*, *Thysomoptera*, *Blattoptera*, *Hymenoptera*, *Psocoptera* and *lepidoptera* principally distributed over the tropics and southern subtropics, such as most species of *Isoptera* and *Blattoptera* living in the mountainous districts of the tropics and subtropics, and north boundary of distribution of few species is only able to extent to warm-temperate zone, but no species of them live in temperate zone and cold-temperate zone (Zhao & Xie 1996; Yuan & Liu 2000; Zhang *et al.* 1990). *Grylloblattodea* lives in temperate zone. *Galloisiana sinensis*, a species of *Grylloblattodea*, is an endemic species that only lives in Changbai Mountain (Zhao & Xie 1996) and has already been selected into roll of rare species to be protected in China. For forest soil fauna in each mountainous area, species numbers and diversity indices of forest soil animal decreased gradually from south to north in eastern China. In middle-small-sized soil animals, *Acarina* and *Collembola* are the dominant groups in forest soil of the eastern mountains. Species and individual numbers of the dominant group of soil macro-animal are different in

the mountainous districts of various temperature zones. For example, *Hymenoptera* is the dominant group in Jianfengling Mountain of Hainan Island in tropical zone. *Myriapoda* is the dominant group in Tianmu Mountain which is in southern subtropical region (Yin *et al.* 1992). *Diptera* is the dominant group in Changbai Mountain which is in temperate region. Resemblance of soil fauna among them is also less, for example, resemblance index of soil animal community between Dinghushan Mountain (in southern subtropical region) and Tianmu Mountain (in subtropical region) was counted to be 0.27, and it is moderately not similar (Yin *et al.* 1992; Liao & Chen 1989a, 1989b).

Ecogeographical distribution

In eastern China, as quantity of heat and rainfall (especially for the former) reduces obviously from south to north, which leads to types of vegetation of each mountainous district appearing distinct change. The common tendency of change is that the compositions of vertical zone of vegetations decrease, and species composition and structure of forest plant

community become simple gradually from the south to the north of China. So there are much types of forest soil animal communities on the mountains of the tropical and subtropical regions, the components of each community were not the same, and similarity of community composition between different mountains was low. In cold-temperate zone, types of forest soil animal community were fewer, but similarity of the components between each community was higher (Zhang *et al.* 1990). Hence, in accordance with the characteristics of soil fauna and above information, we could get a result that the complexity of community structure and abundance of composition of forest soil animal, and types of their community, all of above had trend to become simple gradually from the tropical to cold-temperate zone. For taxa numbers, they are separately 27, 22, 18 from Jianfengling Mountain to Dinghushan to Tianmu Mountain, and orders of H (Shannon diversity index) are 1.82, 1.41, 0.64 (Yin *et al.* 1992; Liao & Chen 1989a, 1989b; Yin *et al.* 2000).

Affected by horizontal climate and vertical climate comprehensively, not only forest soil animal communities of each mountainous districts are obvious different from each other, but soil animals in various forest habitats of the same mountain also differ in the composition of species and quantity properties of the community, and so on. As regards vertical composition of vegetation of a mountain, basal zone should be local type of zonal forest, but in the lower part of basal zone, zonal forest vegetation has been destroyed by human, which led to disorder of zonal characteristics, while in the upper part of basal zone, by reason of good climate condition and less influence of human there are some zonal original forest or hypo-living forest. For example, the foot of the Hengshan Mountain forest is artificial conifer forest while evergreen broadleaf forest distributes in elevation range of 700-1260 m. The foot of Taishan Mountain was surrounded by urban area, where vegetation is pine and deciduous broadleaf mixed forest, which is mainly artificial planting *Platycladus orientalis*, while zonal deciduous broadleaf forest distributes in elevation range of 780-1000 m. In the foot of Changbai Mountain vegetation is deciduous broadleaf forest, whereas zonal pine and deciduous broadleaf mixed forest distributes in elevation of about 750 m. Above three mountains, though, they are located in different geographical position and vertical composition of their vegetation are different from each other, the sort and individual numbers of soil animal are all the greatest in zonal forest habitat. For both taxa and individual numbers of soil animal are less in zonal forest than in zonal forest on the same mountain, and the tendency of change is to decrease gradually with rising of elevation. Hence, in

this region taxa and individual numbers of soil animal, especially for the later, increase with raise of elevation in certain range (from vegetation of the foot of mountain to zonal forest), but they will decrease when elevation rise further and go beyond this range (Yuan & Liu 2000; Zhang *et al.* 1980; Chen 1990; Wang & Zhang 1989).

Forest vegetation grew up well in the mountainous districts of the eastern China. There are a great deal of forest litters that congregate to surface layer of soil and provide soil animal with rich organic matter. Moreover, oxygen content is higher and water is rich in surface layer, and temperature is higher than that of deep layer. Therefore, most of soil animals mainly live in surface layer of soil. As the depth of soil increases, organic matter get less, and changes of soil physical and chemical properties don't profit existence of soil animals, so animal taxa and individual numbers gradually decrease in each following layer. The common change tendency of taxa and individual numbers in different soil layer is in order of $A > AB > B$ (A is the layer of litterfall and humus, AB is the transitional part between the layer of humus and the sedimentary layer, and B is the sedimentary layer), which shows soil animal congregating to surface layer of soil is very marked. For this tendency of congregating to surface layer of soil, individual numbers is more obvious than that one of taxa numbers (Yuan & Liu 2000; Zhang *et al.* 1990; Liao & Chen 1989a, 1989b; Zhang *et al.* 1980; Chen 1990; Liao *et al.* 1997; Chen *et al.* 1990; Wang & Zhang 1989).

With change of climate in a year, seasonal changes of forest soil animal in mountainous districts have their own peculiarity in each temperature zone of eastern China. In warm tropics and subtropics the organic matter of surface layer can be decomposed rapidly and easily washed away. Meanwhile, soil water is rich and temperature is so high that the quantity of oxygen in soil decreases greatly, which don't benefit soil animal to exist. For above reasons, the common tendency in the changes of forest soil animal is as follows: faunal diversity is lower in spring-summer than in autumn-winter, and the lowest in summer. From warm-temperate zone to cold-temperate zone, for winter is severe cold and dry, the speed of decomposition of the organic matter comes to the lowest level very quickly, while in summer rainfall and temperature all are rich and forest vegetation grew luxuriantly. So the tendency of faunal diversity change in mountains of this region shows that diversity is higher in summer than in spring-autumn, and the lowest in winter. In each soil layer, there is an obvious seasonal change for taxa, individual numbers and biomass of soil animals. The highest ones of above three indices in organic matter layer and half-litter all appear in summer, But in litter

layer and interim layer these indices are higher in winter-spring than in summer-autumn, because the temperature of the upper soil layer in winter is lower than that of the lower soil layer and soil animal of the upper layer moved to the lower layer. In addition, because soil animal themselves have various biological and ecological features, there is different season of growth for different animal taxa or different species of same taxa. For example some species grow in all season within a year and others only live in some season of a year (Yin *et al.* 1992; Zhao & Xie 1996; Liao & Chen 1989a, 1989b; Yin *et al.* 2000).

Because the regions of Eastern China has been influenced by the human activities for long time, original forest vegetation have been changed strongly and almost were replaced by secondary forest and artificial forest. From investigating result, we can see that the more heavier human disturbance, the more serious deforestation and as a result, the lower diversity of soil animal was. For instance, Liao (1997) studied soil animal of three forests in Guangzhou suburban district, which were disturbed by different degree of human activities. The result showed that taxa numbers of soil animal was in order of nature secondary forest > pine and broadleaf mixed forest > *Pinus massoniana* forest. In this study case, nature secondary forest was protected completely, pine and broadleaf mixed forest was influenced slightly by human, *P. massoniana* forest was disturbed strongly and near the plough.

Our study on forest soil animal in Taishan Mountain also proved the relationship between soil fauna and human activities (Yuan & Liu 2000). Most of tourists principally gather to the south slope of Taishan Mountain, the human activities has made extreme impact on forest habitats, while there were fewer tourists in the north slope and anthropogenic influence was less. Therefore, in the south slope, community structure for *P. orientalis* forest, *P. densiflora* forest and *Robinia pseudoacacia* forest were simple and there were a few plant speices within forest, and soil is dry and hard too. So taxa and individual numbers of soil animal in three types of forest are lower than those in *P. tabulaerormis* forest of the north slope. In three types of forest of the south slope, *R. pseudoacacia* forest is deciduous broadleaf forest and its dropping matters can be decomposed easily, its litter should be more superior to those in *P. orientalis* forest and *P. densiflora* forest. But because the former is close to Zhongtianmen where anthropogenic influence was extreme, taxa and individual numbers of soil animal are lower than those of the later. Above studies suggested that the diversity of forest soil animal is positively correlated with the quality of forest habitat while it is negatively corre-

lated with human disturbance.

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